STAT:5400, 22S:166
Computing in Statistics

More on R

Lecture 7
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Factors in R

- vector object used to specify a discrete classification (grouping) of the components of other vectors of the same length
- default way of storing character data in data frames
- used in formulas in R
- used in `tapply` function

Example

```
> help(state,package="datasets")
state                package:datasets                R Documentation
US State Facts and Figures

Description:

     Data sets related to the 50 states of the United States of America.

Usage:

     state.abb
     state.area
     state.center
     state.division
     state.name
     state.region
     state.x77

Details:

     R currently contains the following "state" data sets.  Note that
     all data are arranged according to alphabetical order of the state
     names.

     'state.abb': character vector of 2-letter abbreviations for the
          state names.

     'state.area': numeric vector of state areas (in square miles).

     'state.center': list with components named 'x' and 'y' giving the
          approximate geographic center of each state in negative
          longitude and latitude.  Alaska and Hawaii are placed just
```



```
          off the West Coast.

     'state.division': factor giving state divisions (New England,
          Middle Atlantic, South Atlantic, East South Central, West
          South Central, East North Central, West North Central,
          Mountain, and Pacific).

     'state.name': character vector giving the full state names.

     'state.region': factor giving the region (Northeast, South, North
          Central, West) that each state belongs to.

     'state.x77': matrix with 50 rows and 8 columns giving the
          following statistics in the respective columns.

          'Population': population estimate as of July 1, 1975

          'Income': per capita income (1974)

          .
          .
          .

          'Area': land area in square miles

Source:
     U.S. Department of Commerce, Bureau of the Census (1977)
     _Statistical Abstract of the United States_.
     U.S. Department of Commerce, Bureau of the Census (1977) _County
     and City Data Book_.

References:
     Becker, R. A., Chambers, J. M. and Wilks, A. R. (1988) _The New S
     Language_. Wadsworth & Brooks/Cole.
```

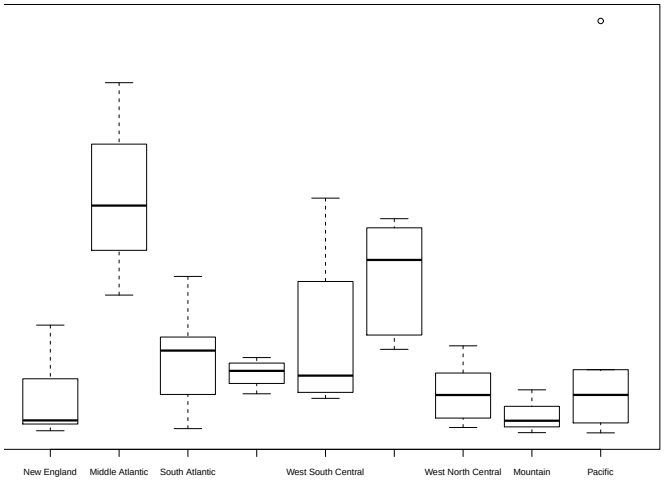
```
> data(state)

> statedf <- data.frame( abb = state.abb, div = state.division,
+ reg = state.region, state.x77[,c("Population","Area")] )

> statedf[1:15,]
           abb               div           reg Population   Area
Alabama     AL East South Central         South       3615  50708
Alaska      AK           Pacific          West        365 566432
Arizona     AZ          Mountain          West       2212 113417
Arkansas    AR West South Central         South       2110  51945
California  CA           Pacific          West      21198 156361
Colorado    CO          Mountain          West       2541 103766
Connecticut CT        New England     Northeast       3100   4862
Delaware    DE     South Atlantic         South        579   1982
Florida     FL     South Atlantic         South       8277  54090
Georgia     GA     South Atlantic         South       4931  58073
Hawaii      HI           Pacific          West        868   6425
Idaho       ID          Mountain          West        813  82677
Illinois    IL East North Central North Central      11197  55748
Indiana     IN East North Central North Central       5313  36097
Iowa        IA West North Central North Central       2861  55941
```


Functions operating on factors

```
> is.factor(statedf[,"div"])
[1] TRUE

> levels(statedf[,"div"])
[1] "New England"        "Middle Atlantic"    "South Atlantic"
[4] "East South Central" "West South Central" "East North Central"
[7] "West North Central" "Mountain"           "Pacific"
```


Using factors in formulas for plotting and model fitting

```
> boxplot( Population ~ div, data = statedf )
> boxplot( Population ~ div, data = statedf, pars=list(cex.axis=0.75))
> dev.copy2eps( file="~/166/lects2005/boxplotstatepop.ps", horizontal=T)
```



```
> summary(lm(Population ~ div, data = statedf ))

Call:
lm(formula = Population ~ div, data = statedf)

Residuals:
    Min      1Q  Median      3Q     Max
-5289.8 -1667.4  -423.6   987.2 15543.2

Coefficients:
                     Estimate Std. Error t value Pr(>|t|)
(Intercept)            2031.2     1500.3   1.354 0.183207
divMiddle Atlantic    10391.8     2598.6   3.999 0.000259 ***
divSouth Atlantic      2087.1     1984.7   1.052 0.299154
divEast South Central  1347.8     2372.2   0.568 0.573013
divWest South Central  3185.8     2372.2   1.343 0.186664
divEast North Central  6157.8     2225.3   2.767 0.008446 **
divWest North Central   353.3     2044.6   0.173 0.863675
divMountain            -828.0     1984.7  -0.417 0.678704
divPacific             3623.6     2225.3   1.628 0.111109
---
Signif. codes:  0 *** 0.001 ** 0.01 * 0.05 . 0.1   1

Residual standard error: 3675 on 41 degrees of freedom
Multiple R-squared: 0.433,      Adjusted R-squared: 0.3224
F-statistic: 3.914 on 8 and 41 DF,  p-value: 0.001645
```



```
> statedf[ statedf["div"] == "Middle Atlantic" ,]
             abb             div       reg Population  Area
New Jersey    NJ Middle Atlantic Northeast       7333  7521
New York      NY Middle Atlantic Northeast      18076 47831
Pennsylvania  PA Middle Atlantic Northeast      11860 44966

> statedf[ statedf["div"] == "East North Central" ,]
          abb               div           reg Population  Area
Illinois   IL East North Central North Central      11197 55748
Indiana    IN East North Central North Central       5313 36097
Michigan   MI East North Central North Central       9111 56817
Ohio       OH East North Central North Central      10735 40975
Wisconsin  WI East North Central North Central       4589 54464

> tapply( statedf[,"Population"], statedf[,"div"], mean )
      New England    Middle Atlantic     South Atlantic East South Central
         2031.167          12423.000           4118.250           3379.000
West South Central East North Central West North Central           Mountain
         5217.000           8189.000           2384.429           1203.125
          Pacific
         5654.800
```


Graphics in R

Plotting functions in base R:

- High-level plotting functions create a new plot on the graphics device, possibly with axes, labels, titles and so on.
- Low-level plotting functions add more information to an existing plot, such as extra points, lines and labels.
- Interactive graphics functions allow you interactively add information to, or extract information from, an existing plot, using a pointing device such as a mouse.

Example of high-level function: Plot

`plot` is a generic plotting function whose behavior is determined by the class of the object(s) to which it is applied.

- argument is factor: bar graph of counts of each level

```
> plot( statedf[,"div"], cex.axis=0.75,
+ main = "Number of States per Division" )
```

- arguments are two numeric vectors: scatterplot with first vector on x-axis

```
> plot( statedf[,"Area"], statedf[, "Population"],
+ xlab = "Area in Square Miles", ylab = "Population in thousands")
```

- argument is a data frame: scatterplot matrix

```
> plot( statedf )
```

- plotting one object against each object in an expression
  - object to left of "∼" will be on y-axis

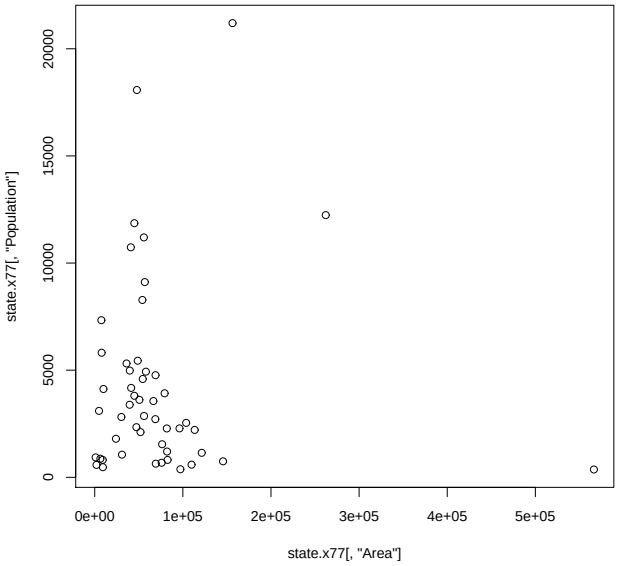
```
> par(mfrow=c(1,2) )
> plot( Population ~ Area + reg, data = statedf )
```

Arguments available in default scatter plot function

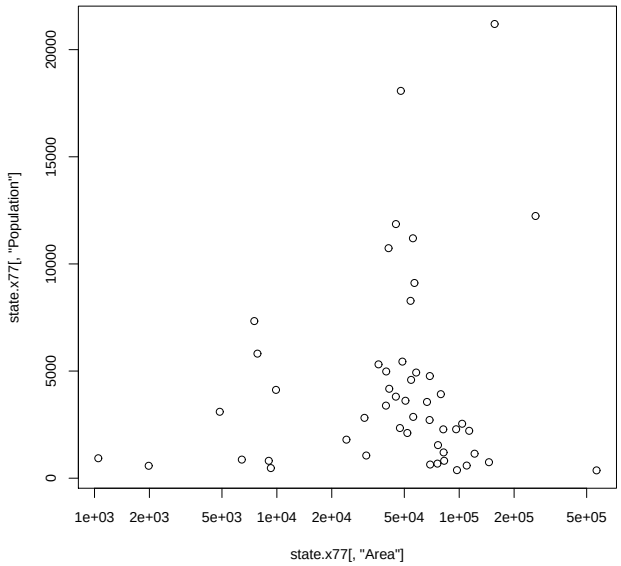
```
> help(plot.default)
plot.default             package:graphics              R Documentation

The Default Scatterplot Function

Description:

     Draw a scatter plot with decorations such as axes and titles in
     the active graphics window.

Usage:

     ## Default S3 method:
     plot(x, y = NULL, type = "p",  xlim = NULL, ylim = NULL,
          log = "", main = NULL, sub = NULL, xlab = NULL, ylab = NULL,
          ann = par("ann"), axes = TRUE, frame.plot = axes,
          panel.first = NULL, panel.last = NULL, asp = NA, ...)
.
.
.
     log: a character string which contains "x" if the x axis is to
          be logarithmic, "y" if the y axis is to be logarithmic and
          "xy" or "yx" if both axes are to be logarithmic.
```


Example

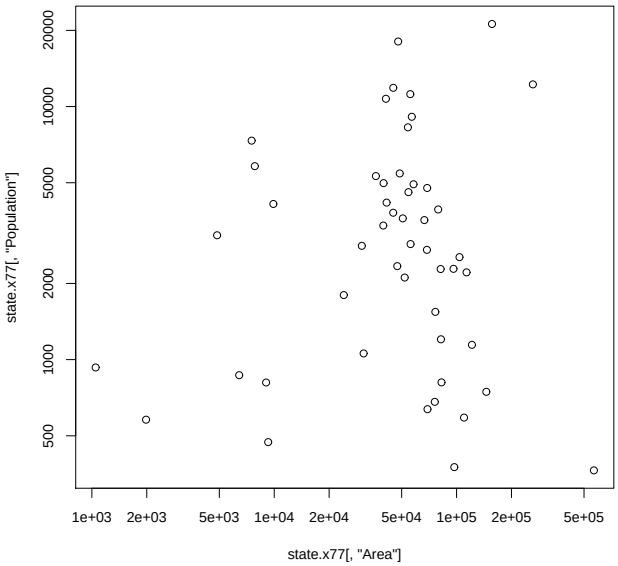
```
> plot( state.x77[,"Area"], state.x77[,"Population"])
> dev.copy2eps(file="~/166/lects2005/rawareapop.ps",horizontal=T)
```




```
> plot( state.x77[,"Area"], state.x77[,"Population"],log="x")
> dev.copy2eps(file="~/166/lects2005/logxareapop.ps",horizontal=T)
```




```
> plot( state.x77[,"Area"], state.x77[,"Population"],log="xy")
> dev.copy2eps(file="~/166/lects2005/logxyareapop.ps",horizontal=T)
```



Low-level plotting functions

- add extra information (such as points, lines or text) to the current plot.
- `points(x,y)`
- `lines(x,y)`
- `text(x,y,labels,...`

```
> attach(statedf)
> plot( Area, Population, type="n" )
> text( Area, Population, abb)
```

- `legend(x, y, legend, ...)`


```
> statedf <- statedf[ order( statedf[,"Area"] ) , ]
> detach(statedf)
> statedf <- statedf[ order( statedf[,"Area"] ) , ]
> attach(statedf)
> Area
 [1]   1049   1982   4862   6425   7521   7826   9027   9267   9891  24070
[11]  30225  30920  36097  39650  39780  40975  41328  44930  44966  47296
[21]  47831  48798  50708  51945  54090  54464  55748  55941  56817  58073
[31]  66570  68782  68995  69273  75955  76483  79289  81787  82096  82677
[41]  96184  97203 103766 109889 113417 121412 145587 156361 262134 566432
> plot( Area, Population )
> lines( lowess( Population ~ Area) )
> lines( lowess( Population ~ Area, f= 0.25), lty = 2)
> legend( 400000, 15000, legend = c("f=2/3","f = 1/14"), lty=1:2)
```


Interactive graphic functions

- `locator( n, type)`
  - Waits for the user to select n locations on the current plot using the left mouse button.
  - returns the locations of the points selected as a list with two components x and y.

```
> text( locator(2), "Outlier")
```


The `apply` family of functions in R

- very much faster than `for` loops that would accomplish the same purpose
- `apply` lets you apply the same function to each row or column of a matrix, and returns results in a vector
- `lapply` applies same function to each member of a list
- `tapply`
- `mapply`